



A320

*Stimulus Isolator*

www.wpiinc.com

## **INSTRUCTION MANUAL**

Serial No. \_\_\_\_\_

0301



### **World Precision Instruments, Inc.**

#### **USA**

International Trade Center, 175 Sarasota Center Blvd., Sarasota FL 34240-9258  
Tel: 941-371-1003 • Fax: 941-377-5428 • E-mail: sales@wpiinc.com

#### **UK**

Astonbury Farm Business Centre • Aston, Stevenage, Hertfordshire SG2 7EG  
Tel: 01438-880025 • Fax: 01438-880026 • E-mail: wpiuk@wpi-europe.com

#### **Germany**

Liegnitzer Str. 15, D-10999 Berlin  
Tel: 030-6188845 • Fax: 030-6188670 • E-mail: wpide@wpi-europe.com

#### **Internet**

[www.wpiinc.com](http://www.wpiinc.com) • [www.wpi-medical.com](http://www.wpi-medical.com)  
[www.nitricoxide.net](http://www.nitricoxide.net) • [www.pipetter.com](http://www.pipetter.com)

**World Precision Instruments**



**WORLD PRECISION INSTRUMENTS, INC.**

175 Sarasota Center Boulevard  
Sarasota, FL 34240-9258 USA  
Telephone: (941) 371-1003 Fax: (941) 377-5428  
e-mail wpi@wpiinc.com

**DECLARATION OF CONFORMITY**

We: World Precision Instruments, Inc.  
175 Sarasota Center Boulevard  
Sarasota FL 34240-9258  
USA

as the manufacturers of the apparatus listed, declare under sole responsibility that the product(s):

**Title: A320D (containing dry batteries)**

to which this declaration relates is/are in conformity with the following standards or other normative documents:

**Safety:** EN 61010-1:1993 (IEC 1010-1:1990)

**EMC:** EN 50081-1:1992  
EN 50082-1:1992

and therefore conform(s) with the protection requirements of Council Directive 89/336/EEC relating to electromagnetic compatibility and Council Directive 73/23/EEC relating to safety requirements.

**Issued on: 18<sup>th</sup> February 2000**

**Dr. Mark P. Broderick  
President and COO**

**World Precision Instruments, Inc.  
175 Sarasota Center Boulevard  
Sarasota, FL 34240-9258 USA**

**Mr. Glen Carlquist  
Production Manager**

**World Precision Instruments, Inc.  
175 Sarasota Center Boulevard  
Sarasota, FL 34240-9258 USA**

# Warranty

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of one year\* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

# Claims and Returns

- Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within 10 days after receipt of shipment. Claims for lost shipments must be made within 30 days of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim settles. In some instances, photographic documentation may be required. Some items are time sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container.
- WPI cannot be held responsible for items damaged in shipment en route to us. Please enclose merchandise in its original shipping container to avoid damage from handling. We recommend that you insure merchandise when shipping. The customer is responsible for paying shipping expenses including adequate insurance on all items returned.
- Do not return any goods to WPI without obtaining prior approval and instructions (RMA#) from our returns department. Goods returned unauthorized or by collect freight may be refused. The RMA# must be clearly displayed on the outside of the box, or the package will not be accepted. Please contact the RMA department for a request form.
- Goods returned for repair must be reasonably clean and free of hazardous materials.
- A handling fee is charged for goods returned for exchange or credit. This fee may add up to 25% of the sale price depending on the condition of the item. Goods ordered in error are also subject to the handling fee.
- Equipment which was built as a special order cannot be returned.
- Always refer to the RMA# when contacting WPI to obtain a status of your returned item.
- For any other issues regarding a claim or return, please contact the RMA department.

**Warning: This equipment is not designed or intended for use on humans.**

\* Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.

# Contents

**Introduction ..... 1**

**Specifications ..... 2**

**Controls ..... 3**

**Quick Instrument Tests ..... 4**

**Operation ..... 5**

    Operation of the A320 is controlled by: .....5

    Free-Running Current Pulsing: .....5

    Voltage .....6

    Stimulation .....7

    Charging the NiCad battery stack, Model A320R .....8

    Changing the batteries .....8

**Warranty ..... 10**

*Copyright © 2001 by World Precision Instruments, Inc. All rights reserved. No part of this publication may be reproduced or translated into any language, in any form, without prior written permission of World Precision Instruments, Inc.*

required or annually. Alkaline batteries in model A320D should not be replaced with NiCad rechargeable batteries as model A320D is not equipped for charging. Batteries are replaced as follows:

Turn POWER switch to OFF. Remove four screws on the bottom surface of the instrument case. Gently remove the entire internal instrument assembly from the outer case by sliding the front panel forward. Unscrew and remove padded cover plate over battery assembly. Firmly, but without wrenching excessively, remove all batteries. Insert new batteries with firm but moderate force. Match the male and female connectors on the battery tops to the mating connectors on the battery printed circuit board. When all batteries have been installed, test the instrument by repeating the "Quick Instrument Tests" outlined above. Reinsert the instrument assembly into the outer case and secure the bottom screws.

**Model A320R** requires 16 Nickel-Cadmium 9-volt batteries. General Electric type TRB-SD1 or equivalent is recommended. Do not remove NiCad batteries from the instrument until they can no longer be recharged. Use WPI's model A362 charger which is specifically designed to charge all of the NiCad batteries together. Nickel-Cadmium rechargeable batteries may require an initial charge depending on their condition when purchased.

effects. Electrolysis can be minimized by maintaining low electrode current density (*i.e.*, large surface area and/or low current) or the use of biphasic (*i.e.*, zero net charge) stimulus current. Biphasic stimuli can be generated by the use of biphasic isolators such as WPI's models **A365** and **A385**.

**TSE-1**, a “chopstick-like” electrode pair (available separately), answers the need for transcutaneous electrical stimulation. Equipped with two removable gold-clad metal spheres, the user can spread the electrode sticks to span the distance between the desired sites on the surface of intact skin. If one ball is removed the resulting small tip allows the exploration of sensitive subcutaneous nerve ending sites because the stimulation current density is higher at the tip of a pointed electrode than at the companion ball electrode. The TSE-1 gold electrode pair comes equipped with twin wire cable and dual banana plug for ready insertion into models A320, A360 or A365 isolated stimulators.

### Charging the NiCad battery stack, Model A320R

With moderate instrument use, freshly charged A320R isolators will often be able to operate for several weeks before recharging becomes necessary. To recharge the battery stack of the A320R, a companion charger, model A362 is required. The charger cable terminates in a 4-pin plug which inserts into the charging receptacle on the rear panel of the A320R stimulator.\* Two red lamps on the charger will light when charging is in progress. The POWER switch on A320R must be OFF for the charger to operate. The A320R battery stack can be recharged in 14 hours (overnight, for example) from a completely discharged state. No serious damage to the batteries will occur owing to overcharge. Do not attempt to charge alkaline dry cell batteries. They may explode!

### Changing the batteries

**Model A320D** requires 16 nine-volt transistor batteries. Alkaline batteries are recommended. Depending on load current usage, the battery stack in model A320D will operate satisfactorily for two or three months or more. Replace batteries when

*\*Disconnect the battery charging cable from the A320R while the instrument is in use. This avoids the possibility that mains frequency noise may be introduced from the charger cable. TURN POWER SWITCH OFF WHEN INSTRUMENT IS NOT IN USE TO PRESERVE BATTERY LIFE.*



## Introduction

Stimulus isolation is needed to assure the precise localization of stimulus current and to prevent current flow from the stimulation site to ground. Models **A320D** and **A320R** are isolated stimulators, battery operated and electrically isolated from ground. A320D is powered by sixteen 9-volt alkaline transistor batteries. Model A320R is powered by 16 NiCad rechargeable cells. These instruments can pulse repetitively at rates and durations controlled by front panel controls and/or be optically pulsed or gated for time durations of a few microseconds to DC, by any WPI pulse generator, standard pulse generator, D to A or interface unit which can provide an adequate output voltage equal to or greater than the threshold command levels specified below.

**WARNING:** High voltage can produce a dangerous electrical shock. Do not apply power while holding bare high voltage wires or connectors.

# Specifications

Output Waveform .....	DC or current pulses
Output Current Ranges .....	1.0 and 10 mA
Current Amplitude Error .....	5% of full scale, max.
Current resolution/repeatability .....	2% of full scale, typ.
Output Load Voltage Range (Compliance)...	100 volts min.
External Command Voltage.....	+5 V nominal (18 V. max. DC)
Output Polarity.....	Reversible, manual switch
On Board Pulse Interval .....	5 ms to 5.5 sec in 3 ranges
On Board Pulse Duration.....	0.05 ms to 0.55 sec in 4 ranges
Current Rise Time + Delay .....	2 $\mu$ s, typ. (1 K $\Omega$ load)
Current Fall Time + Delay.....	10 $\mu$ s, typ. (1 K $\Omega$ load)
Impedance, Output To Ground .....	10 <sup>12</sup> $\Omega$ shunted by <12 pF
Optocoupler, Min. Breakdown Voltage.....	2500 Volts AC
Power	
Model A320D .....	16 alkaline 9V batteries
Model A320R .....	Rechargeable NiCad stack (Requires model A362 charger)

current pulses to voltage pulses as described above using a resistor as a dummy load. Therefore connect a resistor of 1 K  $\Omega$  across the OUTPUT terminals. Connect the two OUTPUT terminals to the input of an oscilloscope. Oscilloscope settings: 200 mV per cm, vertical sensitivity, DC coupled and 1 millisecond per cm sweep speed. In FREE RUN mode, set frequency to 200 Hertz (INTERVAL= 5 ms) and WIDTH to 1 millisecond (.1 ms x 10). Set the controls as follows: RANGE to 1 mA, AUDIO to OFF, POLARITY to RED +. Dial CURRENT to 1.0 mA) and turn the POWER switch to ON. When the oscilloscope is synchronized, 1 Volt pulses (5 cm on the scope) should be observed. Note the shape and speed of the rising and falling edges. They should be fast and smooth.

The true speed of a current pulse generator can be best seen using low values of shunt resistance, as in the example above. As the load resistance increases to 10 K  $\Omega$  and larger, the effect of shunt capacity will be to slow the rising and falling edges of the voltage waveform. It should be noted that in connecting the oscilloscope to view the A320 output, one output terminal usually will be connected to ground by the attached oscilloscope.

## Stimulation

A320 can produce high voltage at its OUTPUT terminals. Take care to avoid accidental electrical shock to the user or to the subject. Always toggle the POLARITY switch to OFF while connecting electrodes. When the POLARITY switch is toggled to Off, the output terminals are disconnected from the stimulus current source and the source is short circuited internally.

The maximum current that an A320 is designed to deliver is 10 milliamperes. For most experiments, this is more than adequate. Since A320D can supply as much as 140 volts to the electrodes, the use of large electrodes and proper skin preparation as well as the use of short pulses will minimize power dissipation and burning of the skin when stimulating cutaneously.

In some experiments, a stimulating current greater than 10 mA may be needed because stimulator electrodes are bathed in fluid electrolyte which shunts much of the inter-electrode current. Model **A385**, a battery operated isolator which can supply up to 100 milliamperes (36 volts max.), is recommended for such applications.

In all stimulation methods, current must flow across a metal to fluid electrolyte interface. An unfortunate consequence is both electrode polarization and possible electrolysis of the fluid. The use of a "constant current" source with a high voltage range minimizes the effect of varying pathway resistance caused by electrochemical

oscillator pulsing. Clearly the pulse WIDTH should not exceed the width of the pulse INTERVAL. If the user inadvertently errs, the red VIOLATION lamp will flash.

Turn the CURRENT knob to zero milliamperes and RANGE switch to x1. Arriving at an optimal stimulation current level is usually an empirical procedure in which the user increases the current gradually from sub threshold values. Toggling the POLARITY switch to RED + connects the electrode pair to the pulsing current source and causes the red OUTPUT terminal to be positive with respect to the black terminal.

**External Pulse Gating:** This operating mode is useful for generating pulse bursts. The on board pulse generator is gated or enabled by application of an EXT INPUT voltage command or by manually pushing the test button. When an EXT INPUT of +5 volts is applied, the PULSE generator will operate as described above in the section on FREE RUN. If the EXT INPUT command is discontinued in the middle of a pulse, the pulse will continue to its proper full width before stopping. Thus all pulses will be identical.

**EXT SYNC:** Single pulses can be initiated by an external trigger applied at the EXT INPUT or by pushing the TEST button. The pulse WIDTH is determined by the setting of the WIDTH knob and its associated range multiplier. The positive leading edge of a +5 volt command or pushing the TEST button will produce one pulse only. Pulses can be made audible (depending somewhat on pulse width) by turning on the AUDIO switch.

**EXT/DC:** In the EXT/DC operating mode the on board pulse generators are not activated. A320 is then a passive stimulus isolator. Output will flow only when a voltage command of +5 volts is applied to the EXT INPUT terminals or when the TEST button is pushed.

## Voltage

A320 can approximate a voltage source by placing a low resistance “dummy” load across the OUTPUT terminals. Resistors such as 100, 1000 and 10,000  $\Omega$  when placed across the OUTPUT terminals convert the generated constant current amplitudes to defined voltage levels. For example 1 milliamperes flowing through 1000  $\Omega$  will produce 1 volt across the OUTPUT terminal pair. Thus, models A320D/R can be used as low noise sources of reproducible voltage pulses. To keep the output voltage constant under load, assure that the OUTPUT dummy resistor not be shunted by loads less than 100 times its own resistance value.

To view easily pulses of current on an oscilloscope it is first necessary to convert

## Controls

**EXT Input:** An external command voltage of 5 volts applied to this BNC connector will result current flow from the OUTPUT. Do not apply a continuous DC input voltage greater than 18 volts.

**Operating mode switch** (upper left): This switch is marked EXT/DC, EXT SYNC, EXT GATE, and FREE RUN. In EXT/DC mode, on board pulsing is disabled and the instrument operates as a passive stimulus isolator/current generator activated manually or by a command voltage applied to the EXT Input.

**TEST:** DC current can be manually generated by pushing the TEST in the EXT/DC mode. With the AUDIO switch ON, operating TEST will result in an audible tone (if the battery supply voltage is adequate). In EXT SYNC mode, pushing the button will elicit a single pulse of duration set by WIDTH controls.

**AUDIO:** When the AUDIO switch is on, an audible tone will sound whenever a stimulus current is being generated. A higher pitched audible signal will also sound, independent of the AUDIO switch, if the OUTPUT voltage exceeds a preset maximum value (the compliance alarm).

**CURRENT mA:** A variable 0 to 1 milliamperes current amplitude control. RANGE: This switch multiplies the CURRENT mA dial setting by x1 or x10.

**INTERVAL:** Two controls; a variable knob from 5 to 55 milliseconds and a X1, X10 and x100 multiplier (below) determine the inter-pulse time interval when the instrument is operated in the FREE RUN or EXT GATE modes.

**WIDTH:** Two controls; a variable knob from .05 to .55 milliseconds and a x1, x10, x100 and x1000 multiplier (below) determine the duration of pulses in the FREE RUN, EXT GATE and EXT SYNC modes.

**VIOLATION:** Red lamp lights if pulse width selected exceeds inter pulse interval.

**POLARITY:** A polarity reversing switch which allows either red or black OUTPUT terminal to be plus. In the OFF position, the output terminals are disconnected from the internal circuit.

**OUTPUT:** Current output terminals. Voltage depends on load resistance and can exceed 100 volts. An audible warning will sound when the maximum load voltage occurs.

**POWER ON/OFF:** Switch connects battery stack power to the A320 stimulator. In the rechargeable version, A320R, charging current is interrupted when the A320 POWER switch is turned ON.

## Quick Instrument Tests

1. Models A320D/R are shipped with fresh batteries and should arrive ready to operate. Switch POLARITY switch to OFF, AUDIO switch to ON, operating mode switch (upper left) to EXT/DC. Turn POWER switch to ON. Note that when TEST switch is operated, an audible tone should be heard. Sound will cease when TEST is OFF. The audio tone indicates battery stack voltage is adequate for operation. (No tone normally indicates battery exhaustion. If no tone is heard on a newly received instrument, check for loose batteries. See section on battery replacement below.)
2. With POWER on, switch POLARITY to RED +. A high pitched tone should sound. This is the “compliance” limit alarm which sounds when the full battery supply voltage is across the output terminal pair, for example, when the output leads are open-circuited.
3. The user may verify the accuracy of the setting on the dial by connecting a milliammeter directly across the OUTPUT connectors and pushing the DC/TEST switch (in the EXT/DC mode). The direction of current flow is determined by which OUTPUT connector has been designated as the anode, *i.e.*, RED + or BLACK + on the POLARITY switch. AUDIO monitoring of the pulses can be switched ON or OFF at the user’s option.

## Operation

All WPI stimulation isolators are primarily designed to supply constant current because current threshold (not voltage) is the most quantitatively reproducible parameter for stimulation of nerve and muscle. Model A320 dispenses current reproducibly from its OUTPUT terminals; the amplitude being determined by the selected current RANGE and the setting of the CURRENT mA dial. Current amplitude is “constant,” that is, load resistance independent, provided that the  $I \times R$  (load) product does not exceed the available battery supply voltage. An audible alarm (the compliance alarm) will sound if  $I \times R$  reaches this limit.

Model A320D with fresh batteries can generate a voltage of 140 volts or more across its OUTPUT terminals. A fully charged NiCad battery stack can produce voltage in excess of 110 volts. Thus, the user can be sure that the amplitude of the current will be as dialed unless the available battery supply voltage is exceeded. The compliance alarm will then be heard. The user then will know that (a) too much current has been dialed for a given load or (b) inter-electrode resistance is too high or the electrode circuit is path open (this is illustrated by Quick Instrument Test #2 above).

### Operation of the A320 is controlled by:

1. Internal PULSE generator (EXT SYNC, EXT GATE or FREE RUN mode), or
2. External voltage command (EXT/DC mode), or
3. Manual operation of the TEST switch.

### Free-Running Current Pulsing:

The pulse INTERVAL knob and its associated decade range switch control pulse frequency. This is continuously variable between 200 pulses per second (pulse INTERVAL = 5 x 1 milliseconds) and 1 pulse per 5.5 seconds (55 x 100 milliseconds). WIDTH and its associated decade range switch determine pulse duration which is continuously variable between 50 microseconds (WIDTH = .05 x 1 ms) and 550 milliseconds (.55 x 1000).

Connect an appropriate pair of stimulating electrodes from the experimental tissue to the red and black OUTPUT terminals respectively. Keep the POLARITY switch in the OFF position to avoid accidental stimulation. Turn POWER to ON. The operating mode switch should be set to FREE RUN, then select an appropriate pulse INTERVAL (frequency) and WIDTH. Toggling the AUDIO switch ON allows the user to hear the